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KNOWLEDGE BASE APPLICATIONS TO ADAPTIVE SPACE-TIME PROCESSING, VOLUME VI: KNOWLEDGE-BASED SPACE-TIME ADAPTIVE PROCESSING (KBSTAP) USER'S MANUAL AND PROGRAMMER'S MANUAL

ITT Systems

Yassir Salama and Roy Senn

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13. ABSTRACT *(Maximum 200 words)*
This User's Manual is intended to be used as a guide for the execution of the Knowledge-Based Space-Time Adaptive Processing (KBSTAP) software. The software has been implemented as a proof-of-concept demonstration to illustrate the advantages of using expert systems techniques in an end-to-end radar system simulation. The software has been built to test the performance of radar systems when knowledge-based rules are applied to filtering, detection, and tracking. Multi-Channel Airborne Radar Measurement (MCARM) data is used as the basis for the evaluation process.

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1.0 Introduction

This User's Manual is intended to be used as a guide for the execution of the Knowledge Base Space-Time Adaptive Processing (KBSTAP) software. The KBSTAP software has been designed and implemented as part of Air Force Research Laboratory (AFRL)/SNRT (Rome, NY) Contract No. F30602-95-C-0041. This effort is a proof of concept to illustrate the advantage of using expert systems techniques in an end-to-end radar system simulation. The software has been built to test the performance of radar systems when knowledge-based techniques are applied to filtering, detection, and tracking sections. The Multi-Channel Airborne Radar Measurement (MCARM) data is used as the basis for the evaluation process. While monostatic MCARM flight No 5 acquisition #575 was used for testing the concept, other flights can be used with minor changes in the software. The software is written in MATLAB®, C++, and C languages. The demonstration platform was a SUN® Ultra 1 running SOLARIS® 2.5. However, the system can run on any UNIX both with MATLAB®, C++, and C Compilers (see System Requirements section).

2.0 Typographical Conventions

This manual uses the following conventions.

Italics	Commands entered at Unix or MATLAB® prompts; for example, *kbstap*.
Bold Italics	Key names, menu names, and items that are selected from menus; for example, ***Auto Run***.

3.0 What is KBSTAP Software

KBSTAP software is a user friendly evaluation tool for evaluating the performance of radar systems when knowledge based techniques are used to control system modules. The software has a graphical configuration dialog box, terrain map display, and simulation results windows. In addition, the package includes a message-based client/server mechanism to exchange messages between different software processes.

4.0 System Requirements

KBSTAP software is written in MATLAB®, C++, and C languages. It runs on a SUN ULTRA workstation with SOLARIS® 2.5 as the operating system. The following is a list of system requirements:

- SUN Workstation ULTRA 1 or higher.
- SOLARIS® 2.5 or higher.
- Recommended 256 MB RAM.
- 300 Mbytes of disk space.
- MATLAB® version 5.1 or higher.
- GNU® C++ compiler version 2.8 or higher.
- SUN professional workgroup C compiler.
- Xwindows X11/R6 or higher.
- Motif window manager

5.0 Installation Procedure

The distribution of the KBSTAP software comes on a 4-mm data tape. To install the software, the user should perform the following steps:

- Mount the distribution tape in the tape drive.

- Change directory to the installation directory where the user wants to install the software. For instance, if the installation directory is /usr/home/kbstap, the user should type the following command at the UNIX prompt:

  $> *cd /usr/home/kbstap*

- If the tape drive is the default magnetic tape drive, the user can extract the software by the typing the following command at the UNIX prompt:

  $> *tar xv*

If the tape drive is not the default drive, the user should add the drive path to the extraction command by typing the following command:

  $> tar xvf /dev/drive_name

where the drive_name is the drive name of the tape used for extracting the software.

- After successful extraction of the files, the user should add the KBSTAP environment variable in the ".cshrc" or ".profile" files depending on the shell used in his/her account. The KBSTAP environment variable sets the distribution kbstap directory for the software. For instance, if the KBSTAP installation directory is /usr/home/kbstap, and the user is using csh, the user should add the following line to the file ".cshrc" in his home directory:

  setenv KBSTAP_DIR /usr//home/kbstap

  If the user uses bourne shell, he/she should add the following lines in ".profile" file in his home directory

  KBSTAP_DIR=/usr/home/kbstap

  export KBSTAP_DIR

- The user can check the successful environment variable setting by typing "*env*" at the UNIX command line. The user should see that the KBSTAP_DIR environment variable is set to the proper installation directory.

6.0 Getting Started

The KBSTAP software is a proof-of-concept utility that enables the user to evaluate the performance of end-to-end radar systems when knowledge based techniques are utilized to control system parameters. The utility is an integration of several software modules that represent different stages of radar signal processing. It includes filtering, CFAR, and tracking processors. In addition, the KBSTAP utility includes a terrain elevation mapping database, a message-based utility for communication between processes, and a graphical user interface configuration utility for adjusting simulation parameters.

After installing KBSTAP software, the user needs to be sure that environment variables are set properly. The environment variables are set in ".cshrc" file if the user uses csh. If the user's default shell is bourne shell, the user needs to set the environment variables in the ".profile" file.

The installation directory where the user installed KBSTAP is considered to be the distribution_directory. For instance, if the user installed KBSTAP in the directory path /usr/home/kbstap, then the distribution_directory in the following examples is /usr/home/kbstap.

The KBSTAP environment variable should be set by adding the following line in ".cshrc"

setenv KBSTAP_DIR distribution_directory.

In case of bourne shell, the user should add the following lines to ".profile"

KBSTAP_DIR=distribution_directory

Export KBSTAP_DIR

In addition to the above environment, the user needs to be sure that the environment variable MATLAB is set to the MATLAB® installation directory and that LD_LIBRARY_PATH is set to point to MOTIF libraries.

After successful installation, the user can run the KBSTAP utility by performing the following steps:

- If open windows is not running, the user needs to run it and open a new window from which to run KBSTAP.

- Change directory to the kbstap_main subdirectory under the KBSTAP distribution_directory. For instance, if the distribution_directory is /usr/home/kbstap, the user should type the following command at the UNIX prompt

  $> *cd /usr/home/kbstap/kbstap_main*

- Run KBSTAP by typing the following command at the UNIX prompt

  $> *kbstap*

- Then the MATLAB® banner will be displayed and the configuration dialog box will show up on the screen.
- The configuration utility comes up with all simulation parameters set to the default values. The user can change the parameters to the required values or he/she can accept the defaults.
- When the user finishes editing the simulation parameters, he/she should click on the ***OK*** button to start the simulation process.
- Once the user clicks on the OK button of the configuration dialog box, the MATLAB® text window will display a list of the parameters out of the configuration dialog box, and the terrain map display window pops up in the screen.
- When the terrain map display window shows up on the screen, the user should watch the MATLAB® window and wait until the communication utility starts up. Communication between processes is well established when the message "NO OP command: ignored" shows up on the MATLAB® window.
- When communication between processes is established, the user can click on the ***Auto Run*** menu button at the menu bar of the terrain map display window to start simulation execution.
- When the simulation is completed, the user clicks on the ***Quit*** menu button at the menu bar of the terrain map display window to exit back to the system prompt.

7.0 Using KBSTAP Software

The KBSTAP software has a front-end configuration Graphical User Interface (GUI) module that is used to set up simulation parameters. The configuration GUI is written in MATLAB® and can be started from the UNIX command line. The configuration GUI interface calls all modules of the KBSTAP software and starts running the simulation. While running, communication between KBSTAP modules is achieved through a client/server message-based utility that is running in the background. The software uses USGS mapping databases such as DEM (Digital Elevation Model) and DLG (Digital Line Graph) data with the SDTS (Spatial Data Transfer Standard) format.

In addition, the software uses both XWindows and MATLAB® graphics to display map and major roads for the simulation engagement terrain.

The major components of the KBSTAP software are configuration, terrain map display, and results showing modules. All modules are controlled through a menu driven graphical user interface.

The software is started from the UNIX command line by typing;

$> *kbstap*

With the configuration dialog, the user can set up the required parameters to run the simulation. Many parameters can be set in the configuration GUI, such as signal, antenna, and

target parameters. The configuration dialog box comes up with the default parameters displayed in the menu boxes. The user can change the default parameters, but the user must make sure that the changed parameters make sense for the simulation process. There are some parameters that the user cannot change due to the fact that this software is a proof of concept and not intended to be a public utility. In addition, the MCARM flight data has peculiar features that are not applicable to other data. In order to accept the many peculiar features of MCARM, and since there was no available data other than MCARM, we had to make this version of the software applicable to MCARM data only. With minor changes in the code, the KBSTAP software tool can work with other data sets.

The configuration dialog box is shown in Figure 1. The description of the parameters of the configuration dialog box will be explained in the following sections. For now, it is enough to know that the configuration dialog box has data boxes for adjusting simulation parameters as well as three buttons at the bottom: ***OK, DEFAULT,*** and ***CANCEL*** buttons.

The ***CANCEL*** button is used to abort all operations and exit from the KBSTAP software. If the user clicks the ***CANCEL*** button, all changes he made to the processing parameters will be aborted.

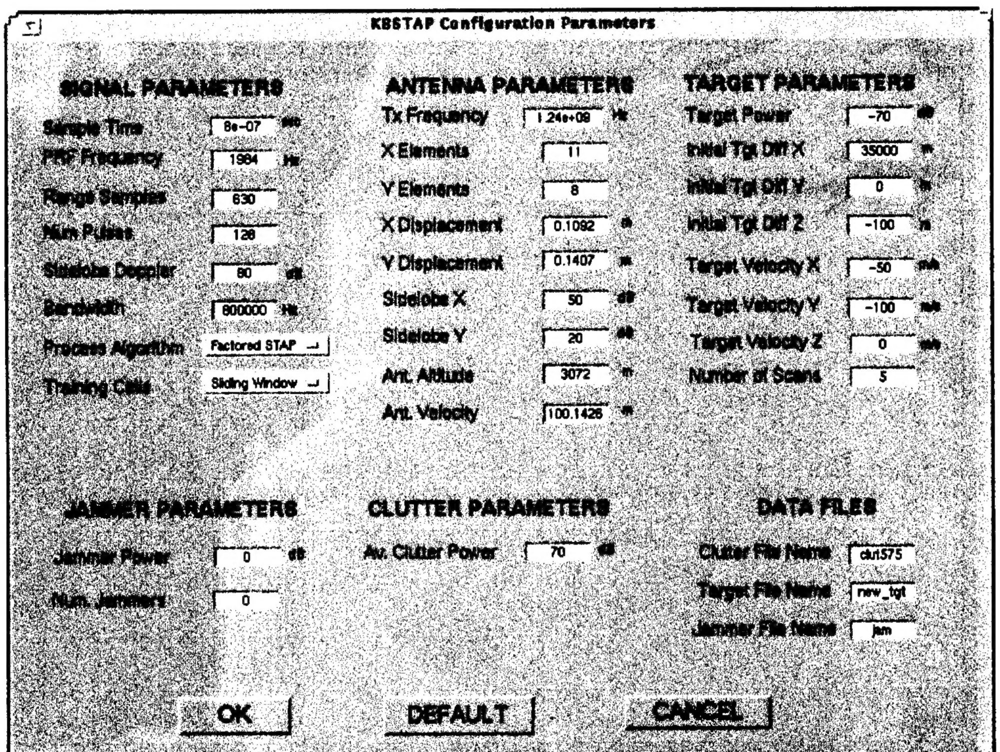


Figure 1: KBSTAP Configuration Dialog Box

If the user makes a mistake and wants to go back to the default parameters, he/she should click on the ***DEFAULT*** button. After changing the required parameters, the user may run the KBSTAP simulation by clicking on the ***OK*** button.

When the ***OK*** button is clicked, the configuration dialog box closes and the map image of the scenario terrain is displayed. The map image shows the terrain elevation and major roads in the area of surveillance.

At the top of the map display, there is a menu bar that has several menu buttons for testing and running the simulation process. To start the simulation process, the user should click on the ***Auto Run*** menu button.

When the ***Auto Run*** menu button is activated, a message is sent to the server running in the background to start the simulation process. During the simulation run-time, text messages are displayed on the text window where the MATLAB® prompt is shown. Figure 2, shows the map image display.

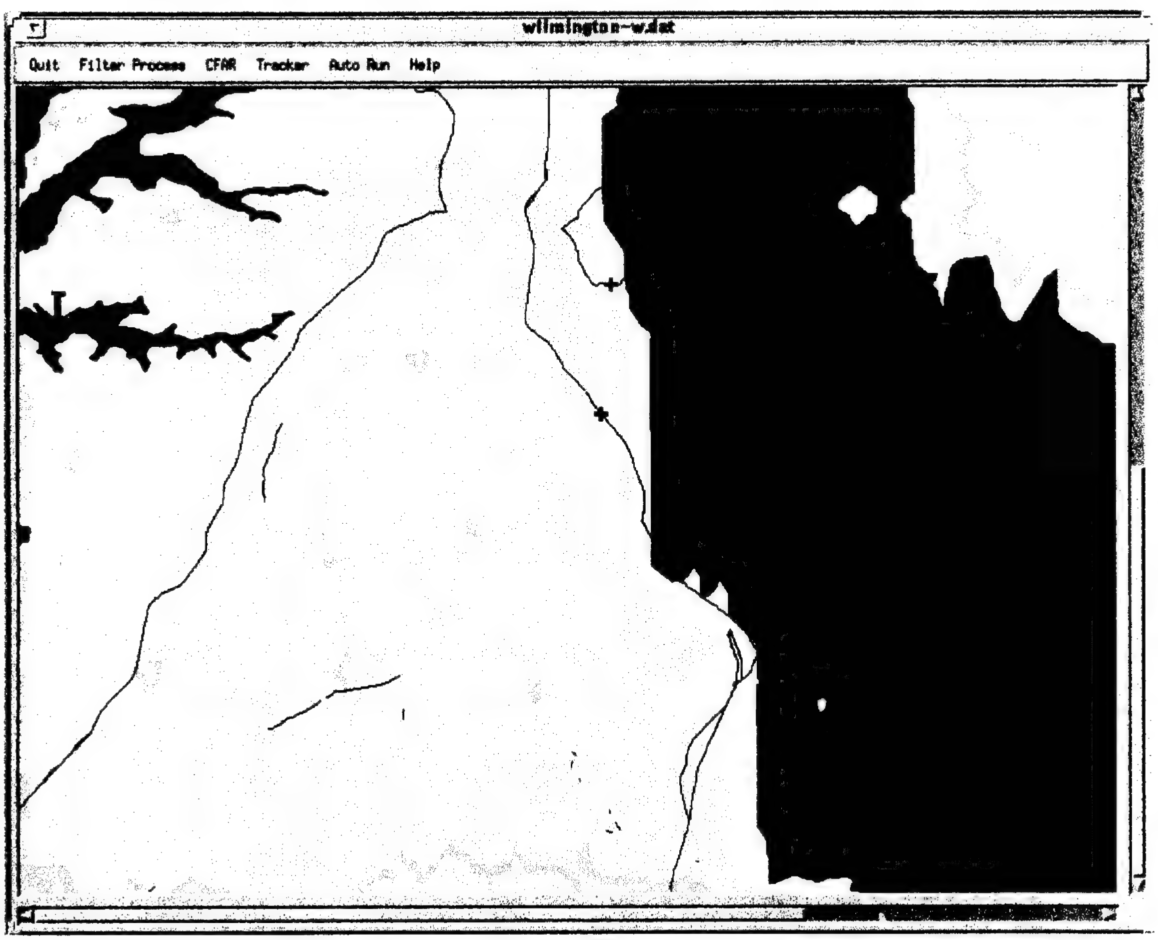


Figure 2: Terrain Map Display Box

The terrain map image displays major roads and platform position as well. The expert system reads information from the MCARM data file and displays intelligent data on the terrain map such as main beam direction and intersections with major roads for the selected range. In addition, the platform icon shows its traveling direction.

During the simulation process, graphical results are shown on separate windows. One of the graphical results windows is the range profile window that is shown in Figure 3.

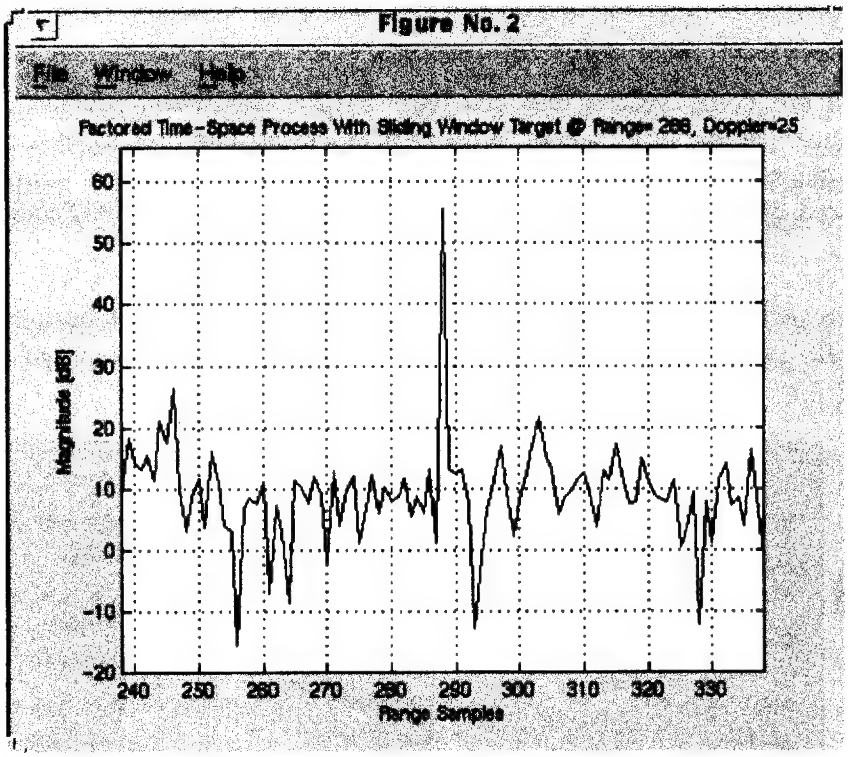


Figure 3: Filter Processing Results Window

The filter-processing window displays the range profile at the target Doppler bin. Other text messages are displayed in the MATLAB® window such as excluded road segments, potential traffic interference angles, and CFAR detections. The text messages are mainly intended for debugging purposes but could also be used for understanding the simulation process.

A reasoning window is at the bottom left corner of the screen, which displays messages indicating the behavior of the system during the course of simulation. The reasoning window messages are terse, but they can be considered as a hookup for more comprehensive messages in future evolution of Knowledge base controlled radars.

The following sections explain the detailed parameters of major components of the KBSTAP software.

8.0 Configuration Window

The main purpose of the configuration window is to provide the user with a graphical way of adjusting the simulation parameters. The configuration window is built in MATLAB® and will start automatically when the user runs the KBSTAP program by typing *kbstap* at the UNIX prompt. The configuration window consists of a group of parameter sections as shown in Figure 4.

The user can enter values of parameters in the data boxes (white background). The data can be entered either by highlighting the current value and writing the new value or by clicking the mouse in the white data box and using the backspace or arrow keys to enter the required values.

There are some values that are flags to the simulation process and do not need a numerical value. In that case, when the user clicks on the data box, a pop-up menu will show up and the user can select any one of the displayed options. The selection is made by a double click on the required option. An example of this kind of parameter is the ***Process Algorithm*** menu option.

At the bottom of the configuration dialog box there are three buttons: ***OK, DEFAULT,*** and ***CANCEL.*** The function of those buttons will be explained at the end of this section.

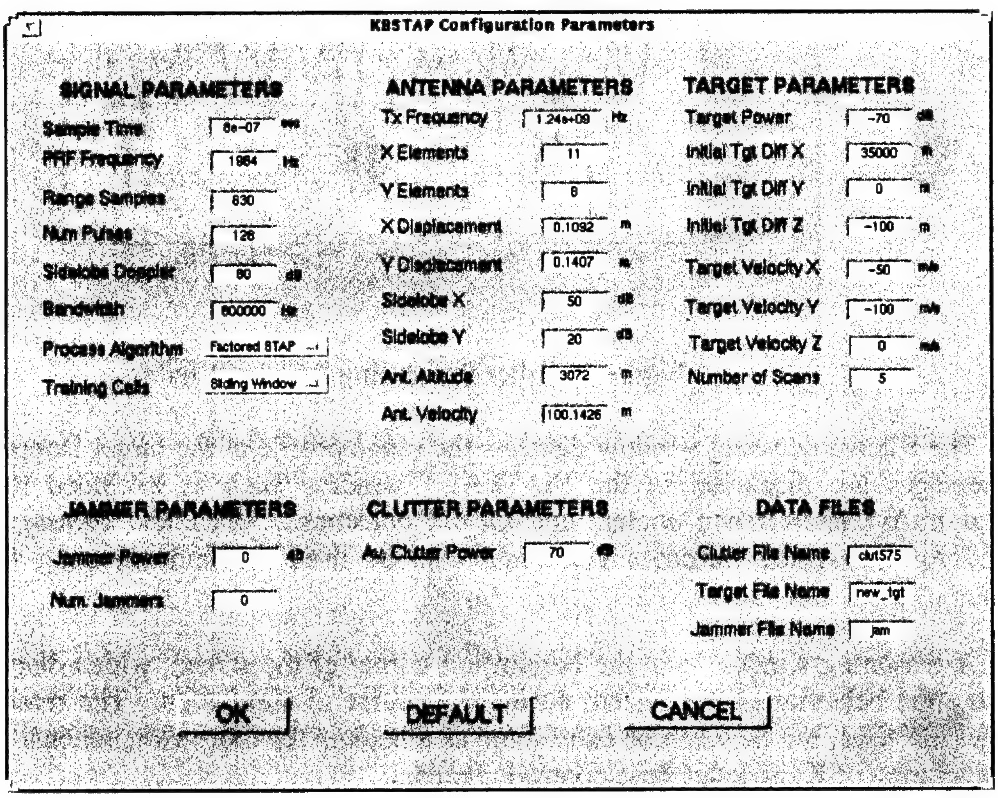


Figure 4: Configuration Dialog Box

The configuration dialog box is divided into parameter sections. The first section in the configuration dialog box is **SIGNAL PARAMETERS**. This section consists of parameters related to the radar signal characteristics. Figure 5 shows the parameters groups under the **SIGNAL PARAMETERS** section.

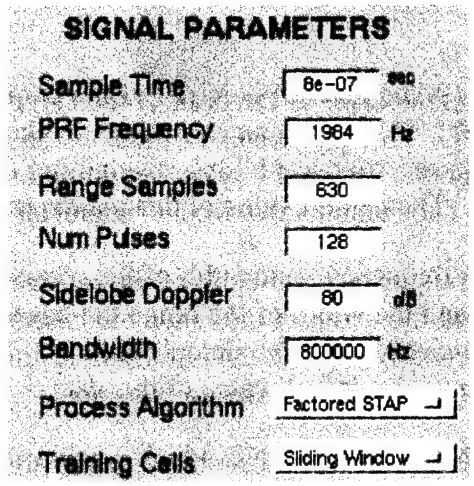


Figure 5: Signal Parameters Section

The parameter list under the **Signal Parameters** section can be easily modified to adapt more parameters needed for other than MCARM data set. The default values for the current parameter list is set for the MCARM data. If the user wanted to use the software for other than MCARM data, minor changes to the software need be made.

The following is a list of the parameters of the **Signal Parameters** section as taken from the configuration dialog box:

- ***Sample Time:*** This is the time between range samples in seconds. The sampling time is considered after decimation. The sampling rate of MCARM data is decimated 4 times. The data was over-sampled by a ratio of 4 to 1. Output from down-converters was digitized with sample time of 0.2 microseconds, which is equivalent to a sample rate of 5 Msamples/sec. After decimation it becomes 1.25 Msamples/sec which gives 0.8 microseconds sample time. The default value for this parameter is 0.8 microseconds. The user can not change this parameter because it is a hardware feature for the MCARM data.

- ***PRF Frequency:*** This is the pulse repetition frequency in [Hz]. MCARM data has three modes of operation related to PRF frequency: Low PRF, Medium PRF, and High PRF. For flight #5 acquisition 575, medium PRF mode was used. In that mode the PRF frequency was 1984 Hz, which is the default value for this parameter. The user can not change this parameter for acquisition 575.

- ***Range Samples:*** This is the number of range samples in a pulse repetition interval (PRI). The default value of this parameter is 630 range samples, which is the number of range samples in the case of medium PRF mode. The user should not change this value unless he is using a different acquisition or different data.

- ***Num Pulses:*** This is the number of pulses in a CPI (Coherent Pulse Interval). The default value of this parameter is 128. The user should not change the default value for this parameter.

- ***Sidelobe Doppler:*** This is the level of the peak of the Doppler filter main lobe relative to the highest sidelobe in [dB]. This parameter is used in the signal processing module where Doppler filtering is required. We used Taylor weighting on the Doppler filter to achieve the required sidelobe level. The default value of this parameter is 80 dB.

- ***Bandwidth:*** This is the frequency bandwidth of the receiver. This parameter determines the resolution of the radar and the width of the range bin based on the assumption that the signal is processed with a matched filter. The default value of this parameter is 0.8 MHz. Again, the user should not change the default value of this data.

- ***Process Algorithm:*** This is a flag input, which signals the simulation process as to which algorithm will be used in the filtering process. The options for this flag are: ***Factored STAP***, ***JDL***, and ***DPCA***. Figure 6 shows the three options for this flag. The default algorithm is ***Factored STAP***.

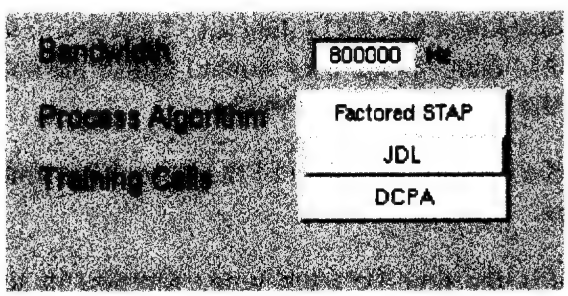


Figure 6: Signal Processing Algorithm Selection

- ***Training Cells:*** This is a flag input, which signals the simulation process as to which method will be used to select training cells. The options for this flag are: ***Sliding Window***, ***NHD*** (Non-Homogeneity Detector), and ***2-STEP NHD***. Figure 7 shows the three options for this flag. The default method of selecting training cells, is ***Sliding Window***.

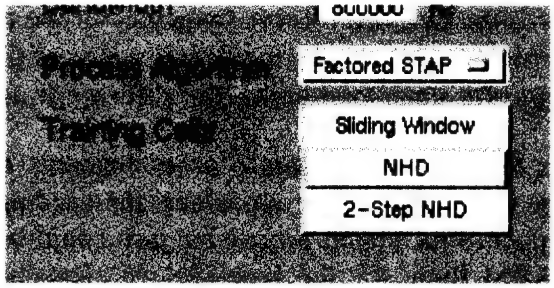


Figure 7: Training Cells Selection Flag Options

The next section of the configuration dialog box is the group of parameters related to the antenna (platform) characteristics. This section falls under the title ***ANTENNA PARAMETERS.*** Similar to the previous section, the list of parameters of the ***ANTENNA PARAMETERS*** section can easily be modified to work with any measured or simulated data. Figure 8 shows the ***ANTENNA PARAMETERS*** section parameters.

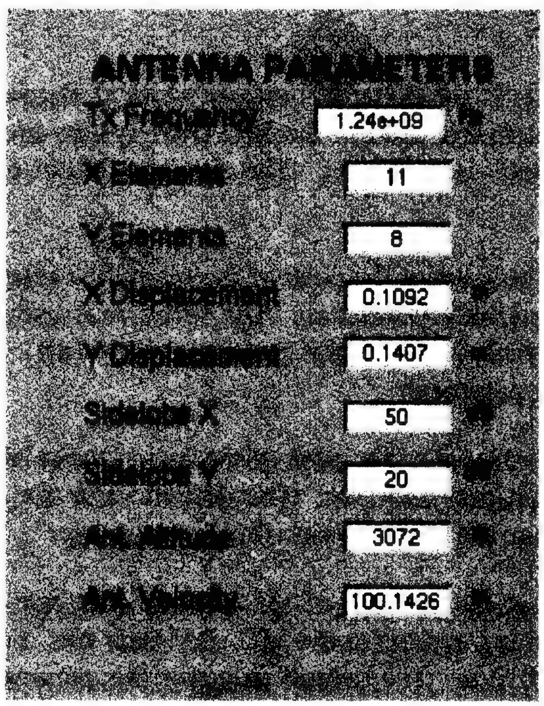


Figure 8: Antenna Parameters Section

The following is a list of the parameters of the ***ANTENNA PARAMETERS*** section:

- ***Tx Frequency***: This is the transmit/receive frequency of the radar system in [Hz]. Since the software is used for MCARM flight #5, the default value of this parameter is 1.24 GHz. The user should not change this parameter unless the software is used for another platform.

- ***X Elements***: This is the number of antenna array elements in the X (Horizontal) direction. Notice that the value of this parameter represents the used antenna manifolds, because – in some cases – the inputs to the signal-processing unit could be a subset of the antenna array. In the case of MCARM flight #5, the array has 16 elements (Radules) in the horizontal direction but only 11 elements are passed to the receiver, in addition to the summation (Σ) and difference (Δ) channels. Thus, the actual number of elements passed to the receiver is 11, which is the default value for this parameter. The user should not change the default value of this parameter.

- ***Y Elements***: This is the number of antenna array elements in the Y (Vertical) direction. The default value of this parameter is 8 elements. The user should not change the default value of this parameter unless another system is simulated.

- ***X Displacement***: This is the distance between horizontal elements of the antenna array in [m]. The antenna array elements used in the MCARM system are equally displaced. The default value for this parameter is 10.92 cm. The user should not change the default value for this parameter.

- ***Y Displacement***: This is the distance between vertical elements of the antenna array in [m]. The antenna array elements used in the MCARM system are equally displaced. The default value for this parameter is 14.07 cm. The user should not change the default value for this parameter.

- ***Sidelobe X***: This is the level of the peak of the main lobe relative to the highest sidelobe peak in [dB] in the X (Horizontal) direction. The software is using Taylor weights to achieve the given value. The default value for this parameter is 50 [dB]. The user should not change the default value for this parameter.

- ***Sidelobe Y***: This is the level of the peak of the main lobe relative to the highest sidelobe peak in [dB] in the Y (Vertical) direction. The default value for this parameter is 20 [dB]. The user should not change the default value for this parameter.

- ***Ant. Altitude***: This is the altitude of the antenna platform in [m]. In MCARM test, the platform information is included in the MCARM data file. For flight #5, acquisition 575, the antenna altitude is 3072 m. The default value for this parameter is 3072 m. The user should not change the default value for this parameter.

- ***Ant. Velocity***: This is the velocity of the antenna platform in [m/s]. In MCARM test, the platform velocity is included in the MCARM data file. For flight #5, acquisition 575, the antenna velocity is 100.1426 m/s. The default value for this parameter is 100.1426 m/s. The user should not change the default value for this parameter.

The next section of the configuration dialog box is the group of parameters related to the simulated (injected) target features. The title box of this section is ***TARGET PARAMETERS***. As mentioned in the previous sections, the list of parameters in this section can easily be modified to work with any other measured or simulated data. Figure 9 shows the ***TARGET PARAMETERS*** section parameters.

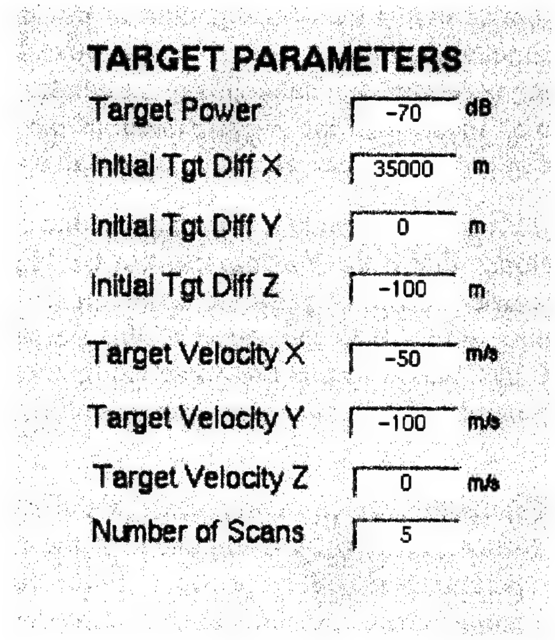


Figure 9: Target Parameters Section

The following is a list of the parameters of the ***TARGET PARAMETERS*** section:

- ***Target Power***: This is the power in [dB] of the injected target relative to 0 dB. The power of the target was chosen to be relative to 0 dB so that the simulation will be independent of the clutter or noise conditions of the system. The power level of the injected target is measured at the receiver inputs. The default value for this parameter is –70 dB. The user can change the value of this parameter to any value.

- ***Initial Tgt Diff X*** : This is the initial distance between the target and the platform in the X (East) direction in [m]. The default value for this parameter is 35Km east of the platform. Notice that the positive X direction is towards east and the negative towards west. The user can change the value of this parameter to any value.

- ***Initial Tgt Diff Y***: This is the initial distance between the target and the platform in the Y (North) direction in [m]. The default value for this parameter is 0 m (i.e. the target and the platform are aligned west-east direction. Notice that the positive Y direction is towards the north and the negative towards south. The user can change the value of this parameter to any value.

- ***Initial Tgt Diff Z***: This is the initial distance between the target and the platform in the Z (Upward) direction in [m]. The default value for this parameter is –100 m down relative to the platform. Notice that the positive Z direction is upwards, and the negative is downwards. The user can change the value of this parameter to any value.

- ***Target Velocity X***: This is the velocity component of the injected target in the X (East) direction in [m/s]. Notice that if the X-component of the target velocity is going east, then the value of this parameter should be positive. In the other hand, if the X-component of the target velocity is going west, then the value of this parameter should be negative. The default value is –50 m/s, which means that the X-component of the injected target velocity is going west with velocity of 50 m/s. The user can change the value of this parameter to any value.

- ***Target Velocity Y***: This is the velocity component of the injected target in the Y (North) direction in [m/s]. Notice that if the Y-component of the target velocity is going north, then the value of this parameter should be positive. In the other hand, if the Y-component of the target velocity is going south, then the value of this parameter should be negative. The default value is –100 m/s, which means that the Y-component of the injected target velocity is going south with velocity of 100 m/s. The user can change the value of this parameter to any value.

- ***Target Velocity Z***: This is the velocity component of the injected target in the Z (Upward) direction in [m/s]. Notice that if the Z-component of the target velocity is going upward, then the value of this parameter should be positive. In the other hand, if the Z-component of the target velocity is going downward, then the value of this parameter should be negative. The default value is 0 m/s, which means that the target is flying in a horizontal path. The user can change the value of this parameter to any value.

- ***Number of Scans***: This is number of iterations the software runs. Each iteration includes reading the data file, computing where the injected target is, and processing the data through filtering, CFAR, and detection. The default value for this parameter is 5 iterations. The user can change the value of this parameter to any value.

The next section of the configuration dialog box is the group of parameters related to the simulated jammers. The title menu box for this section is ***JAMMER PARAMETERS***. As mentioned in the previous sections, the list of parameters in this section can easily be modified to work with any other measured or simulated data set. Figure 10 shows the ***JAMMER PARAMETERS*** section parameters.

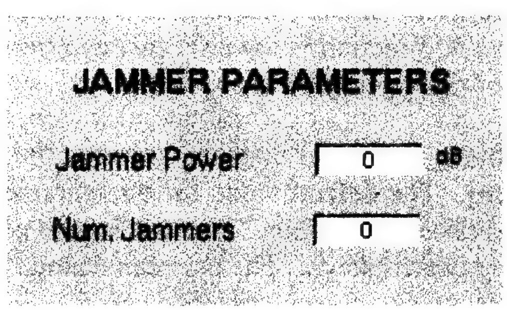


Figure 10: Jammer Parameters Section

The following is a list of the parameters of the ***JAMMER PARAMETERS*** section:

- ***Jammer Power***: This is the power in [dB] of the injected jammer relative to 0 dB. The power of the jammer was chosen to be relative to 0 dB so that the simulation will be independent of the clutter or noise levels of the system. The power level of the injected jammer is measured at the inputs of the receiver. The default value for this parameter is 0 dB. This feature is not implemented in the current release of the software. It is introduced as a hookup for future implementation of the software.

- ***Num. Jammers***: This is number of injected jammers in the simulated scenario. The default value of this parameter is 0, which means no jammers are injected in the data. The user should not change the default value of this parameter.

The next section of the configuration dialog box is the group of parameters related to the simulated clutter features. The title box of this section is ***CLUTTER PARAMETERS***. As mentioned in the previous sections, the list of parameters in this section can easily be modified to work with any other measured or simulated data set. Figure 11 shows the ***CLUTTER PARAMETERS*** section parameters.

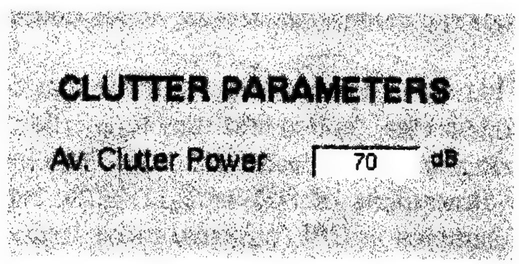


Figure 11: Clutter Parameters Section

The following is a list of the parameters of the ***CLUTTER PARAMETERS*** section:

- ***Av. Clutter Power***: This is the average power in [dB] of the simulated clutter relative to 0 dB. The average power of the clutter was chosen to be relative to 0 dB so that the simulation will be independent of the system parameters. The default value for this parameter is 70 dB, however, this parameter is not implemented in the current release of the software and has no impact on the simulation process. The user should not change the default value of this parameter.

The next section of the configuration dialog box is the section of the input files, which are used by the software. The title box of this section is ***DATA FILES***. The input files have a special format and should not be changed unless all requirements are satisfied. Figure 12 shows the ***DATA FILES*** section parameters.

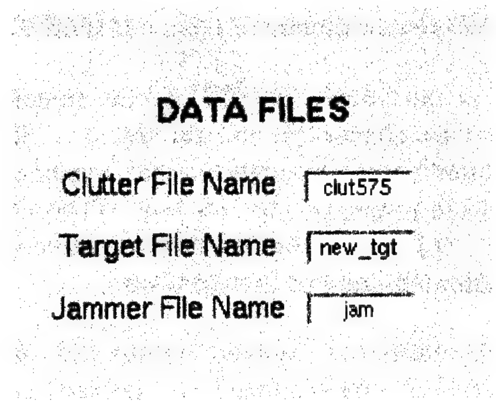


Figure 12: Data Files Section

Data files used by KBSTAP software are MATLAB® files in the native MATLAB® format with extension (*.mat). The extension is not required in the entries of file names, the software assumes that the extension is ".mat". The current release of the software does not accept any other format.

The following is a list of file names and default values under the section of ***DATA FILES***.

- ***Clutter File Name***: This is the name of the input file that contains radar data reflected from the terrain clutter and discretes. Notice that the clutter file may contain target data too. It is the digitized data coming out of the radar receiver. The clutter data file contains an array of complex values with dimensions of 80640 X 11. The size of each column in the matrix equals the number of samples in CPI (coherent pulse interval). The samples are distributed such that the range samples of the first PRI come first then the range samples of the next PRI and so on until the last PRI of the data. The number of columns in the clutter matrix is the number of antenna array elements in the X-direction. Notice that the data of the clutter matrix represents the summation of all of the vertical elements of the antenna array that have the same X coordinate and combined as one horizontal channel. Thus, the MCARM data are represented as 11 horizontal channels. The input clutter data file is generated from the MCARM data file "rl050575.mat" using the utility "convmcarm.m". The clutter matrix variable is called "ClutSignal". The default file name is "clut575". The user should not change the default name for the clutter file.

- ***Target File Name***: This is the name of the input file that contains the radar data for the simulated injected target. This option is used if the target is not generated during the simulation time. This file is used only for testing purposes but is still a valid input. The current release of the software includes two options: either load target data from file, or generate an injected target during the course of the simulation process. The input target data file contains data received from a simulated point target. The data is arranged such that one range sample corresponding to the target range is recorded per PRI. Thus, the target data is a complex matrix with dimensions of 128 x 11, where the number of rows of the matrix equals

the number of PRI's in the CPI, and the number of columns of the matrix equals the number of the antenna array elements in the X-direction. For the purpose of simulating non-point targets, a reference signal is added to the target data file. The reference signal represents the LFM modulated waveform of the transmitted signal. The target data file contains two variables: "TgtVector", which is 128 X 11 complex data, and "RefSignal", which is 630 X 1 complex data. The default target file name is "new_tgt". The user should not change the default name of this file.

- ***Jammer File Name***: This parameter is not used in the current release and has no effect on the simulation process. In future releases, this can be used as a link to introduce jammers and examine the performance of the system in the presence of different types of jammers. The user should leave this menu box as it is.

The next section of the configuration dialog box is the control section. The control section contains three buttons: ***OK***, ***DEFAULT***, and ***CANCEL***. Figure 13 shows the control section of the configuration dialog box.

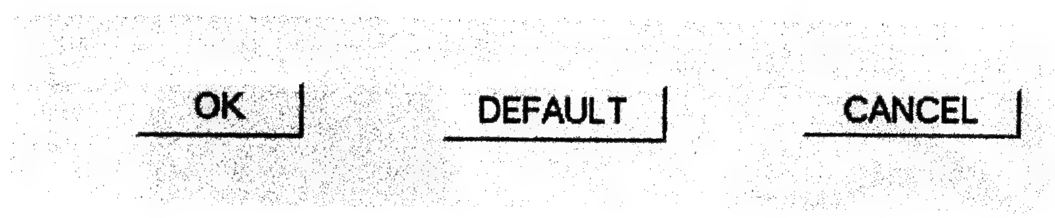


Figure 13: Control Section

The control section assists the user in controlling the execution of the KBSTAP simulation process. It consists of the following buttons:

- ***OK*** Button: This button is used to start the KBSTAP simulation process. Once the user finishes adjusting all parameters, the simulation starts by clicking the ***OK*** button. This button invokes all components of KBSTAP including the filtering, CFAR, and tracking processes. All components of KBSTAP run from a MATLAB® environment, which is started when the user types *kbstap* at the UNIX command line. Some of the components of KBSTAP are written in C++ and C languages. Those modules are called from MATLAB® environment and are dealt with as callable functions or subroutines. At the end of the simulation process, the system exits and comes back to the UNIX prompt. Notice that if the user changes a value that should not be changed, an error message will be displayed in the MATLAB® window. The error message says:

  "ERROR: Configuration parameters are not supported. This is a proof of concept software. It works with MCARM flight #5 acquisition # 575. The only parameters that can be changed are those of the target."

When the user gets this error message, he can go back to the configuration dialog box and redo his changes. Or the user can click on the ***DEFAULT*** button to restore all default values.

- ***DEFAULT*** Button: This button is used to restore the default values for all system parameters. This button is useful especially when the user changes a value that should not be changed and he/she wants to go back to the default values.

- ***CANCEL*** Button: This button is used to cancel all editing and exit to the system command line.

9.0 Terrain Map Display Window

When the user clicks on the ***OK*** button of the configuration dialog box, the terrain map display window shows up. The terrain map display contains a terrain elevation and major roads map of the scenario engagement field. In addition, at the top of the window there are menu button controls that the user needs to run the actual simulation. Figure 14 shows the details of the terrain map display window.

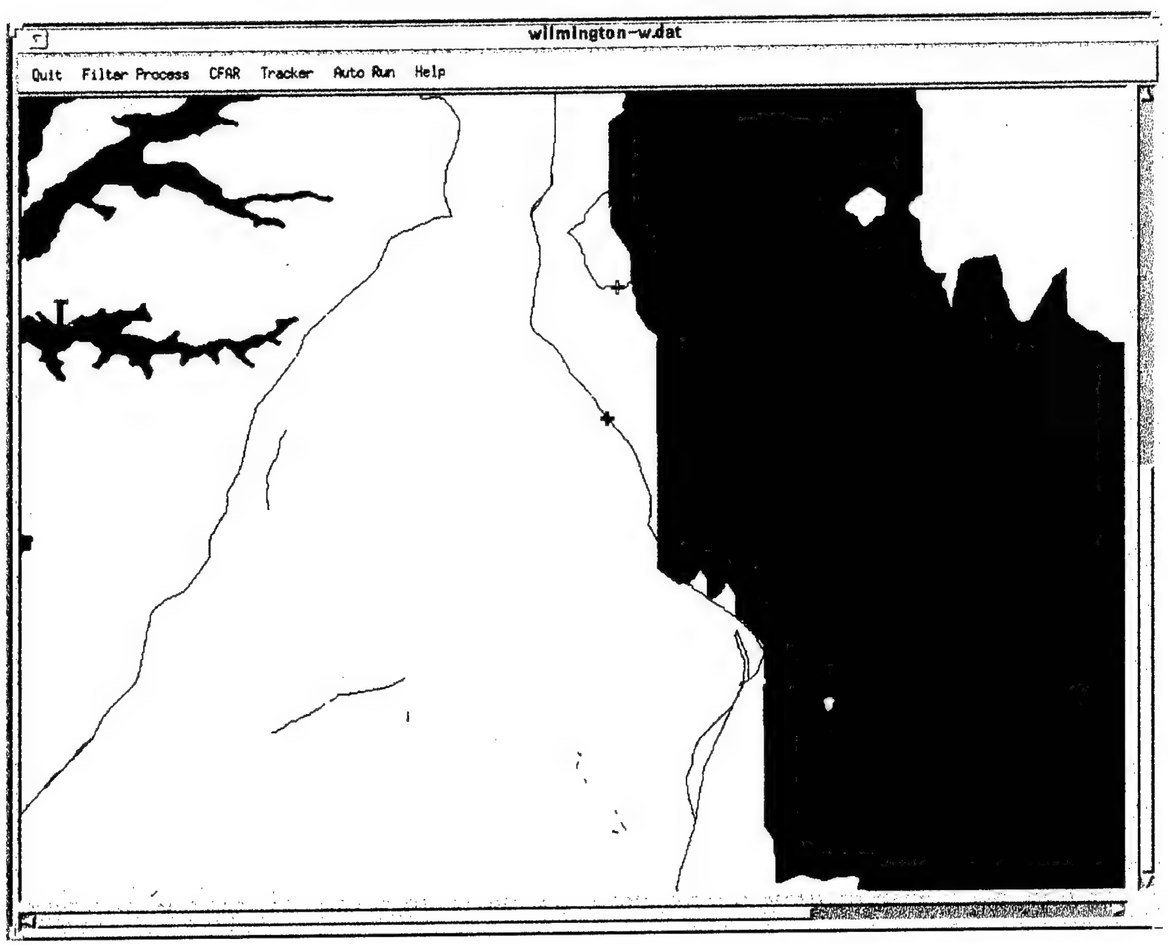


Figure 14: Terrain Map Display Window

The title of the terrain map display window indicates the name of the area of the terrain. In MCARM flight #5, the window displays the terrain elevation of " West Wilmington ".

In addition, the terrain map display contains an icon resembling the position of the platform and its flight direction. Out of the platform icon come two dashed lines to represent the main beam scan. Crosses are displayed at the intersection of major roads with the selected target range bin.

Notice that the terrain elevation map is color-coded with 64 color levels based on the elevation of the terrain. The lowest elevation level is given a blue color just to give the user an idea of where sea level is. The blue color is not intended to define water areas because of the fact that there are large land area surrounding the water area with elevation close to the sea level. The water area information is used in the database of the knowledge-based controller to find out clutter interface areas. The display of water areas is not implemented in the current release of the software.

The terrain map display window contains the following control menu buttons at the top menu bar:

- ***Quit*** Button: Is used to exit to the system command line.
- ***Filter Process*** Button: Is used for testing purposes only.
- ***CFAR*** Button: Is used for testing purposes only.
- ***Tracker*** Button: Is used for testing purposes only.
- ***Auto Run*** Button: Is used to start the simulation program. When this menu button is clicked, a message is sent to the server. The server recognizes this message and starts all components of KBSTAP software including; filter, CFAR, and tracking processes.
- ***Help*** Button: Is used to display a short help message. Figure 15 shows the help message displayed when the user clicks on the ***Help*** button.

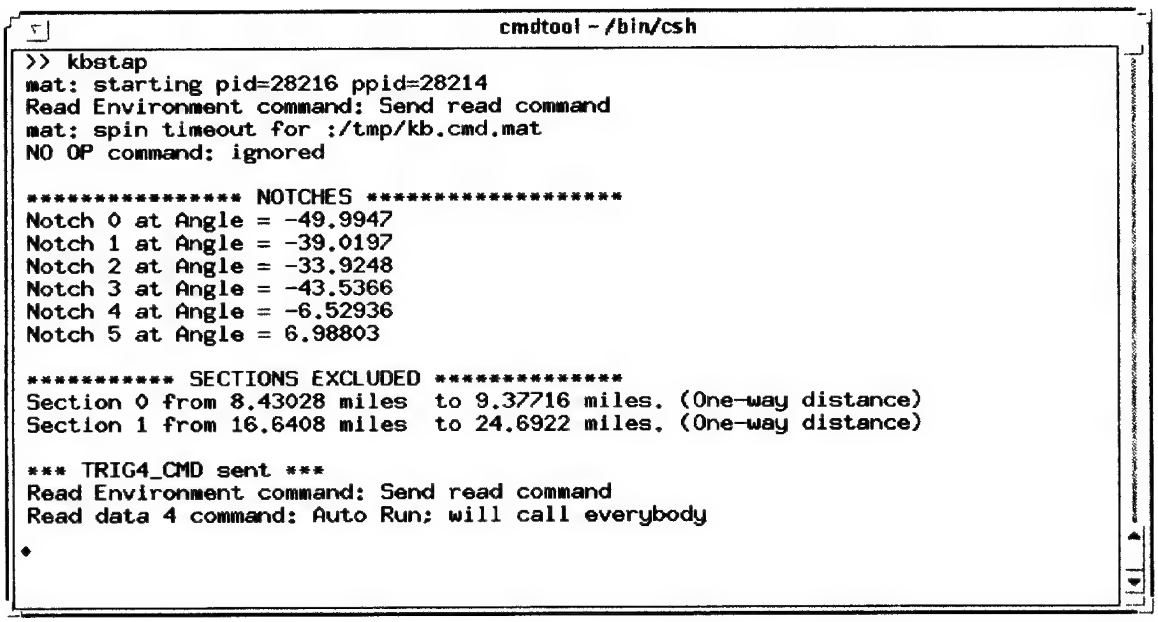
Figure 15: Help Message Window

The help message is just an example of the help text. It is not intended to be a comprehensive help. In future releases, help messages may be changed to be more comprehensive and linked to the conditions when the help was invoked.

10.0 Simulation Results Displays

In the KBSTAP software, the results of the simulation process are displayed during the course of simulation. There are four windows to display the results; a text window, reasoning window, range profile window, and the tracking window. The following is an explanation of the simulation results windows.

- **The Text Window**: The text window is the MATLAB® window. It is used to display all text and debugging messages that are produced during the run-time of the simulation process. Figure 16 shows an example of a text message display.



```
cmdtool - /bin/csh
>> kbstap
mat: starting pid=28216 ppid=28214
Read Environment command: Send read command
mat: spin timeout for :/tmp/kb.cmd.mat
NO OP command: ignored

**************** NOTCHES ******************
Notch 0 at Angle = -49.9947
Notch 1 at Angle = -39.0197
Notch 2 at Angle = -33.9248
Notch 3 at Angle = -43.5366
Notch 4 at Angle = -6.52936
Notch 5 at Angle = 6.98803

*********** SECTIONS EXCLUDED **************
Section 0 from 8.43028 miles  to 9.37716 miles. (One-way distance)
Section 1 from 16.6408 miles  to 24.6922 miles. (One-way distance)

*** TRIG4_CMD sent ***
Read Environment command: Send read command
Read data 4 command: Auto Run: will call everybody
```

Figure 16: Text Message in the Text Window

The text messages displayed in figure 16, are examples of the expert system decisions about sections to be excluded from the secondary data due to the likelihood of having traffic interference in these sections. Also, displayed in figure 16 are the possible notches that may be inserted in the antenna pattern to avoid intersections with major roads. In addition, many messages will show up in the text window such as messages from the CFAR process and the expert system road correlation algorithms.

- **The Reasoning Window**: The reasoning window displays messages indicating some of the reasoning behind the decisions made by the knowledge base controller. An example of one of the messages displayed in the reasoning window is shown in Figure 17.

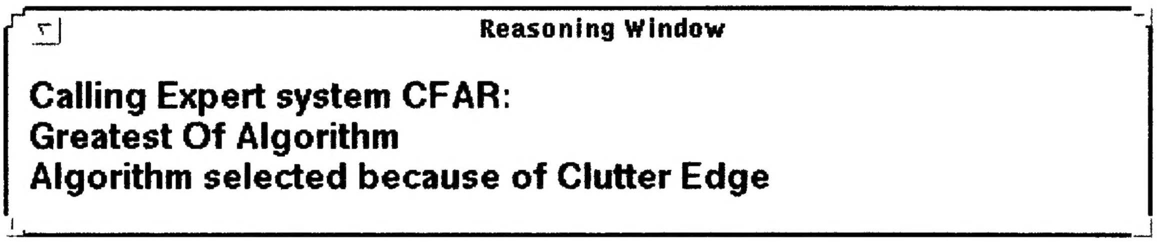


Figure 17: Message Displayed in Reasoning Window

The message displayed in Figure 17 shows the reason that led to the selection of the greatest-of CFAR algorithm. The reasoning window still needs more comprehensive messages to explain the underlying process. Hopefully, in future evolution of the KBSTAP software, we can provide better method and better text for all knowledge base reasoning.

- **The Range Profile Window**: The output of the filtering process is displayed in the range profile window. The range profile is displayed at the target Doppler bin as determined by the filtering process. An example of the range profile display is shown in figure 18.

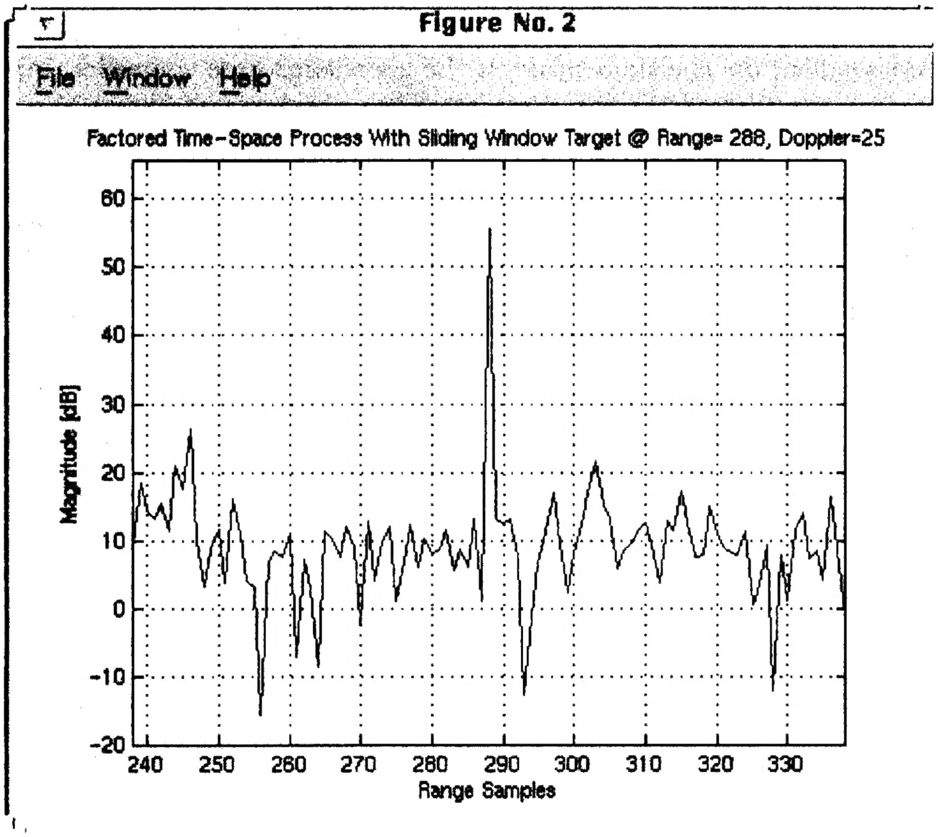


Figure 18: Range Profile Window

The title of the range profile window indicates which algorithm was used and the method of selecting secondary data cells. In addition, it displays the detected target range and Doppler bins. The plot in the range profile window changes during the simulation course to display the current detection results as it is processed.

- **The Tracking Window**: The tracking window displays the outcome from the tracking process. The background in the tracking window is the same as that of the terrain map display window. Target detections are displayed as "*" shapes overlaid on the map as reported by the tracker. The positions of tracker reports are translated into map coordinates. Error tracking gates are displayed as ellipses as shown in Figure 19.

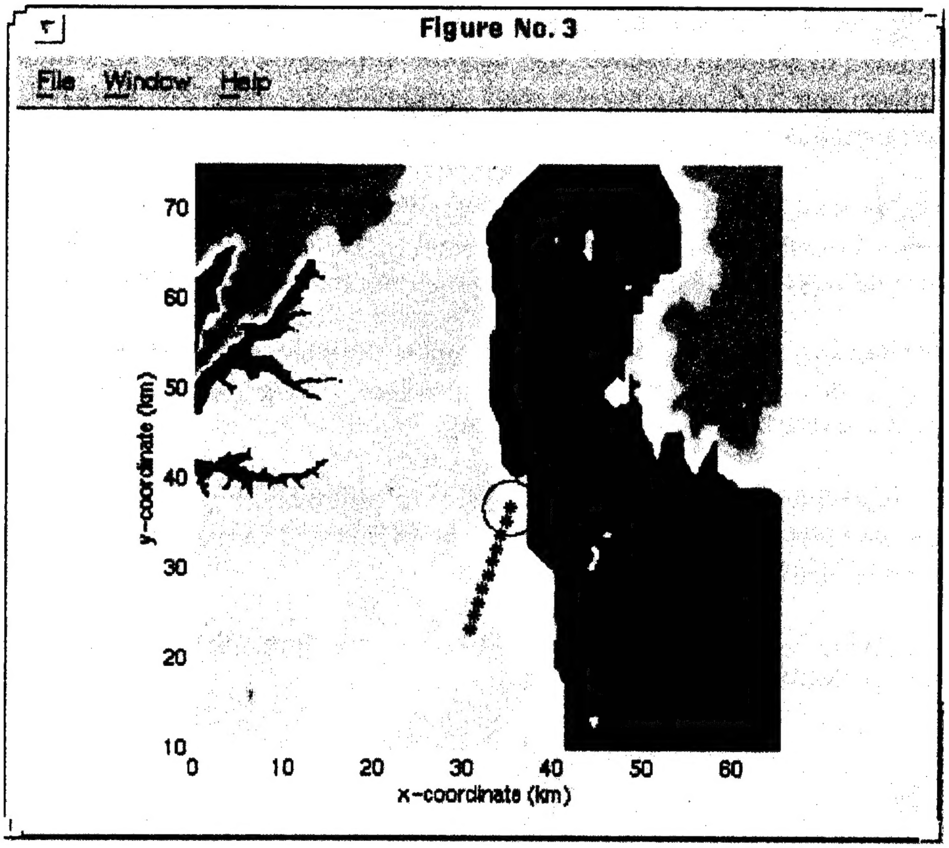


Figure 19: Tracking Window

Figure 19 shows a target flying in the direction of southwest at an initial distance of about 35Km from the platform. The first detection of the target was declared as tentative track and the error gate was open wide to look for the next detection of the same target. Once the track is established, error gates shrink to small sizes. When zooming in, the user can see the error gates surrounding the reported target detections. For more information, the user is referred to the KBSTAP final report for an explanation about the tracking process.

11.0 Work to be Done Next Releases

The current release of the KBSTAP software is a proof-of-concept release. It was designed to run with MCARM data for flight #5 acquisition 575. There are some features that we would like to provide in future releases of KBSTAP. The following is a list of things that will improve the performance of the KBSTAP software:

- General Purpose Tool: We would like to add more features to the current release so that the KBSTAP software could be used as a general-purpose simulation tool. The suggested tool should be flexible enough to accept more formats similar to MCARM data. The tool should support bistatic radar operation mode as well.

- More Algorithms: We would like to add more algorithms to the currently implemented algorithms. In addition to space-time adaptive processing (STAP) algorithms, we would like to explore non-STAP algorithms such as parametric adaptive matched filter and cross spectral methods.

- Better Map Display: We would like to improve the map display features to include hydrographic, and Land Use and Land Cover (LULC) features. The current implementation includes hydrographic features in the database only but not reflected in the map display.

- Better Help Messages: We would like to improve the helping mechanisms such that the user can easily find out context-based help messages. Also, help messages should be more comprehensive and include a tutorial session.

- Better Reasoning Mechanism: We would like to improve the reasoning mechanism such that the user can receive continuous and more comprehensive messages about underlying process of the knowledge based controller.

- More Tracking Algorithms: We would like to add more tracking algorithms and improve tracking performance.

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